

AN APPRAISAL OF *GAZORYCTRA* HÜBNER
(HEPIALIDAE) AND DESCRIPTION OF A
NEW SPECIES FROM ARIZONA AND NEW MEXICO

DAVID L. WAGNER¹

Department of Entomology, California Academy of Sciences,
Golden Gate Park, San Francisco, California 94118

AND

NORMAN B. TINDALE

Honorary Research Associate, South Australian Museum,
North Terrace, Adelaide, S.A., Australia, 5000

ABSTRACT. *Gazoryctra* includes 10 species from North America, and 3 from N Europe and Asia. Seven Nearctic species of *Hepialus* are transferred to *Gazoryctra*: *hyperboreus* Möschler, *lembertii* Dyar, *mathewi* H. Edwards, *novigannus* Barnes & Benjamin, *pulcher* Grote, *roseicaput* Neumoegen & Dyar, and *sciophanes* Ferguson. *Gazoryctra wielgusi* is described based on 94 males from the White Mountains of Arizona and adjacent New Mexico. A checklist of *Gazoryctra* is included.

Additional key words: *Gazoryctra wielgusi*, *Hepialus*, systematics, Holarctic.

Gazoryctra Hübner are medium-sized swift moths found in high latitudes or alpine habitats of the Holarctic Region. They are handsome moths, with brown, orange, or pinkish forewings and silvery white maculations. Adults of most species fly in late summer or fall. They are exceptionally strong fliers, particularly the diurnal arctic-alpine species. Many have very brief periods of diurnal activity, flying for only 20 or 30 min during evening twilight.

All previously known *Gazoryctra* were described in the nominotypical genus *Hepialus* Fabricius (or *Epialus* Lederer). North American *Gazoryctra* have been referred to as the "hyperboreus group" by Barnes and Benjamin (1926) and Ferguson (1979). Members of this group were incorrectly placed in *Phymatopus* Wallengren by Pfitzner (1912, 1937-38). Viette (1949) alone recognized that some Nearctic hepialids should be classified in *Gazoryctra*.

The purpose of this paper is to provide adult, pupal, and larval characters for the recognition of the genus, to clarify which elements of the Holarctic hepialid fauna belong to *Gazoryctra*, to validate nomenclature changes for the North American species, and to describe a new species from the southwestern United States.

¹ Present address: Department of Ecology and Evolutionary Biology, 75 North Eagleville Rd., Room 312, U-43, Storrs, Connecticut 06268.

Background

Hübner ([1820]:198) established three genera for the heterogeneous Palearctic swift moth fauna occurring in N Europe: *Gazoryctra*, *Pharmacis*, and *Triodia*. In his synopsis of the generic classification of European Hepialidae, Viette (1949) designated *Bombyx ganna* as type species of *Gazoryctra*. He characterized *Gazoryctra* as having a lobed valva and a toothlike trulleum in male genitalia, and further noted that small apical tibial spurs were present on middle and hind legs. He transferred to *Gazoryctra* the Palearctic *Hepialus macilentus* Eversmann and the Nearctic *H. confusus* H. Edwards and *H. mcglashani* H. Edwards. Later, Viette (1953) noted that *Gazoryctra* species also had prominent earlike lobes in the intersegmental membrane between abdominal segments 8 and 9 (socii of Robinson 1977, tergal lobes of Nielsen and Kristensen in press), and added a fifth species to the genus, *H. fuscoargenteus* Bang-Haas.

Many lepidopterists have overlooked or ignored the generic concepts of Hübner [1820], Wallengren (1869), Börner (1925), and Viette (1948, 1949), and have continued to treat most Holarctic swift moths as members of the nominotypical genus *Hepialus* (McDunnough 1939, Heath 1976, Ferguson 1979, Davis 1983). In North America, Hepialidae have been classified into two genera: *Hepialus* (type species: *humuli* Linnaeus) and *Sthenopsis* Packard (type species: *quadriguttatus* Packard). Most lepidopterists have recognized *Sthenopsis* from the time of its proposal in 1865 (Packard 1865, Kirby 1892, Neumoegen & Dyar 1894, Wagner & Pfitzner 1911, Forbes 1923, McDunnough 1939, Davis 1983). However, our studies indicate that *Hepialus humuli* and members of *Sthenopsis* (with *Zenophassus* Tindale, *Aenetus* Walker, and perhaps others) have a common ancestor not shared by most other Holarctic Hepialidae. Synapomorphies for these taxa include (1) a metatibial hairpencil in males; (2) swollen metatibiae in males (members of the *Sthenopsis regius* group and some *Aenetus* lack hairpencils and swollen metatibiae, but these appear to be reversals within the clade); (3) triangular forewings with falcate apices; (4) forewing scales with rounded apices; and (5) absence (loss) of the epiphysis in all but *Aenetus* and *Sthenopsis argenteomaculatus* (Harris). In addition, all members of this group are larger than most other Hepialidae and exoporian Lepidoptera, with forewing lengths typically exceeding 4 cm. Consequently, if *Sthenopsis* is to be retained as a distinct genus, then names proposed for more distantly related taxa like *Gazoryctra* warrant at least generic status.

Gazoryctra in North America

So that we could reliably assign the hepialid described here to a genus, we prepared dissections of all the Holarctic hepialid generotypes.

We also examined all North American hepialid extant primary types, and prepared genitalia and wing slides for all named Nearctic and many European species, including all examined by Viette (1949).

In addition to the characters given by Viette (1949), eight others were found to be shared by *Gazoryctra* species: (1) forewing subcosta forked (vein Sc₁ well developed); (2) halves of tegumen meeting dorsoanteriorad, but free over much of midline; (3) dorsal margin of tegumen bearing dense oval patch of spinules; (4) caudal portion of trulleum not fused to tegumen; and (5) pulvilli large and setose. In the larva, (6) claw elongate, with basal tooth ending before ½; (7) D2 and SD setae on prothorax not grouped. In the pupa, (8) caudal band of teeth encircling abdominal segment 7 broken ventrolaterad.

Our studies indicate that *Gazoryctra* is the largest genus of North American Hepialidae. In addition to the two Nearctic species identified by Viette (1949), seven other described hepialids were found to share this list of characters and are transferred here to the genus *Gazoryctra*.

Checklist

In what follows, subspecific names are indicated by a), and are but tentatively recognized. Author names followed by year do not necessarily refer to literature cited in this paper.

Gazoryctra Hübner [1820]

Gazoryctes Kirby 1892, missp.

confusa (H. Edwards 1884) (*Hepialus*)

fuscoargentea (Bang-Haas 1927) (*Hepialus*)

sordida (Nordstrom 1929) (*Hepialus*), infrasubsp.

a) *postmaculata* (Landin 1943) (*Hepialus*)

ganna (Hübner [1810]) (*Bombyx*)

artica (Boheman 1848) (*Hepialus*)

reducta (Deutsch 1925) (*Hepialus*), infrasubsp.

confluens (Hellweger 1914) (*Hepialus*), infrasubsp.

chishimana (Matsumura 1931) (*Hepialus*), infrasubsp.

hyperborea (Möschler 1862) (*Epialus*), **new combination**

lembertii (Dyar 1894) (*Hepialus*), **new combination**

macilenta (Eversmann 1851) (*Hepialus*)

gerda (Staudinger 1897) (*Hepialus*)

a) *nesiotes* (Bryk 1942) (*Hepialus*)

mathewi (H. Edwards 1875) (*Epialus*), **new combination**

matthewi (H. Edwards 1884), missp.

mcglashani (H. Edwards 1887) (*Hepialus*)

mcglachanii (Pfitzner 1912), missp.

noviganna (Barnes & Benjamin 1926) (*Hepialus*), **new combination**

novigana (Pfitzner 1937-38) (*Hepialus*), missp.

a) *mackiei* (Barnes & Benjamin 1926) (*Hepialus*)

pulchra (Grote [1865]) (*Hepialus*), **new combination**

roseicaput (Neumoegen & Dyar 1893) (*Hepialus*), **new combination**

mutata (Barnes & Benjamin 1926) (*Hepialus*), infrasubsp.

demutata (Barnes & Benjamin 1926) (*Hepialus*), infrasubsp.



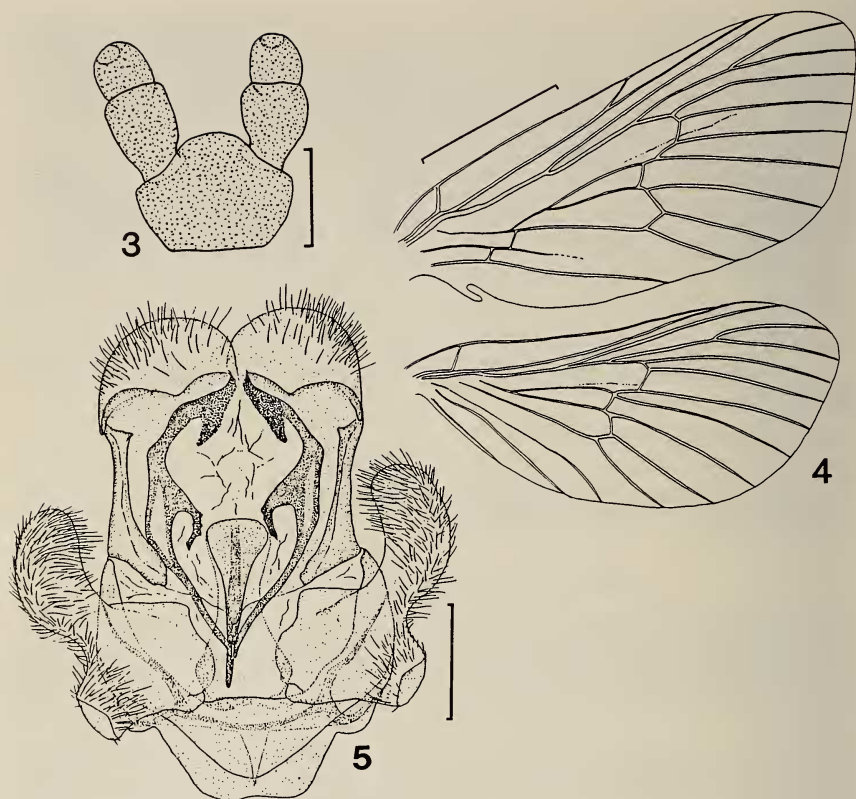
FIGS. 1, 2. *Gazoryctra wielgusi*. 1, Holotype male; 2, Paratype males from Ditch Camp. White scales replaced by silvery gray scales in lower right-hand specimen. Label data in text.

sciophanes (Ferguson 1979) (*Hepialus*), new combination
wielgusi Wagner & Tindale, new species

Gazoryctra wielgusi, new species

This pink and silvery moth is so far known only from a restricted area in the mountains of E Arizona and W New Mexico. Terminology for genital structures follows Birket-Smith (1974), Ueda (1978), and Nielsen and Robinson (1983); for wing veins, Nielsen and Robinson (1983); and for scale ultrastructure, Downey and Allyn (1975) and Kristensen (1978b).

Male (Figs. 1–11). Forewing length 15–18 mm (N = 94). **Head.** Antenna with 29–32 segments (N = 10), flagellomeres slightly compressed with abundant short setose sensory setae (Figs. 6, 7), yellow to orange-brown. Head vestiture dense admixture of buff and darker piliform scales; dark or dark-tipped scales prominent over frons, labial palpus, and ventral region. Labial palpus with 2 subequal segments (Fig. 3), vom Rath's organ dorsosubapical. **Thorax.** Pro- and mesothoracic dorsum with brown-tipped and buff piliform scales intermixed; metathorax buff. Procoxae and pro- and mesofemora dark-scaled. Tibiae and tarsi with elongate salmon-colored lamellar scales and contrasting dark fusiform scales (Fig. 8). **Venation** (Fig. 4). R_{2+3} branched at mid-length; hindwing vein CuP obscure in some specimens, and 2A differentiated from wing cuticle. **Scales** (dorsal surface over median region) (Figs. 10, 11). Broadest beyond middle, apices 3- or 4-toothed; secondary ridges prominent; windows small, circular to elliptical, diameter less than $\frac{1}{2}$ interridge distance, surrounded by ring of unmodified cuticle, separated by 1 to 3 transverse flutes; window membrane occasionally present; flutes prominent with perpendicular secondary ribbing between adjacent flutes. Forewing tan or brown to peach or salmon with peppering of darker scales; heavily maculated with silvery white (rarely silvery gray) markings, these outwardly edged with dark scales; submarginal spots nearly always present, occasionally fused with oblique submarginal band; white spots or streaks also along subcosta and base of inner margin. Hindwing uniformly brown with orange or salmon-colored scales along margin, at apex, and extending basally along veins; apex faintly patterned. Fringe of both wings orange or salmon. **Abdomen.** Dorsum of segments 1 and 2 uniformly covered with long pale piliform scales; segments 3 to 8 with both long buff scales and lamellar salmon-colored scales. **Genitalia** (Fig. 5). Tergal lobes prominent, densely setose dorsad and laterad, hemispherical, with ventrolateral digitate lobe extending below margin of tegumen. Caudal margin of tegumen with 2 sets of ventrally projecting, strongly melanized processes, upper pair digitate and angled ventrad, apices with single prominent tooth and several smaller distal teeth; lower pair gradually tapering to



FIGS. 3-5. *Gazoryctra wielgusi*. 3, Labium: scale = 0.2 mm (DLW Slide 86-63); 4, Wing venation: scale = 0.5 cm (DLW Slide 86-62); 5, Male genitalia: scale = 0.5 mm.

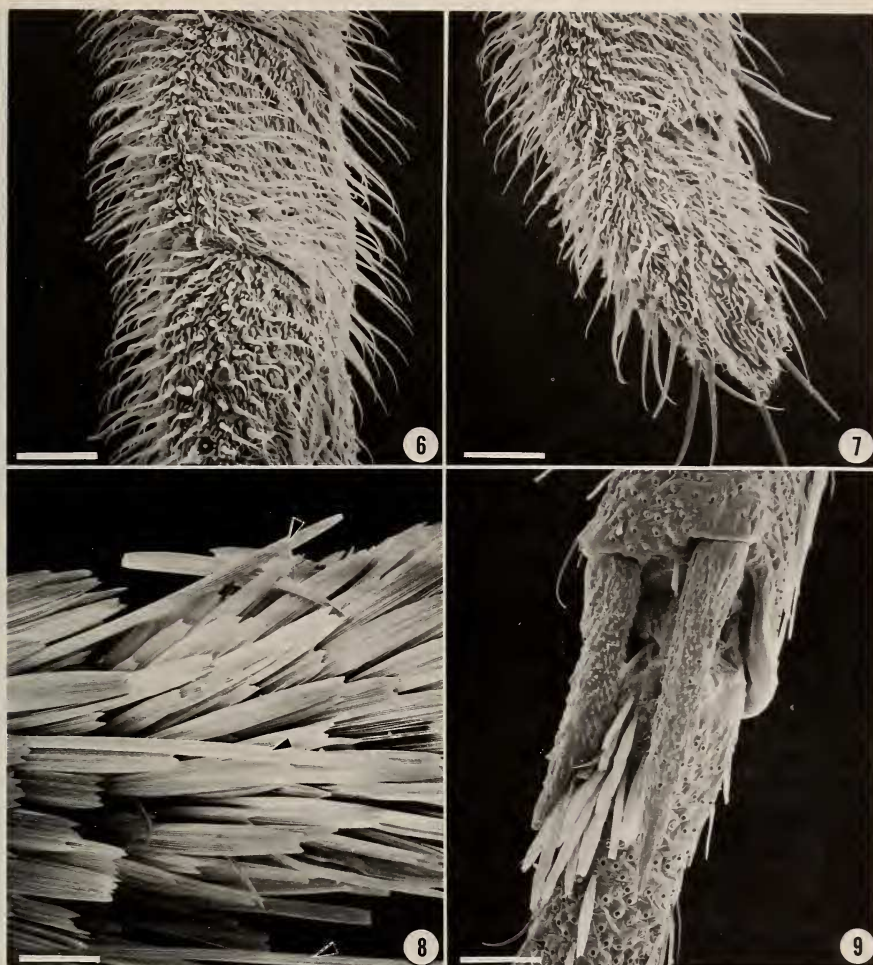
points, apices approximate over midline. Trulleum long, narrow, tapering to strongly melanized spine. Valva densely setose, boot-shaped; lower lobe rounded, curving mesad; inner margin notched above basal articulation. Juxta elongate, constricted in middle; roughly pentangulate. Vinculum often emarginate ventrolaterad.

Female. Unknown.

Diagnosis. A heavily maculated species with silvery white streaks and spots along base of inner margin, subcosta, and termen between medial veins. It can be readily separated from other strongly marked *Gazoryctra*—*confusa*, *hyperborea*, *pulchra*, and *roseicaput*—by its dark brown hind wings with contrasting orange or salmon-colored fringe. The oblique submarginal band is continuous, never broken into separate spots as is often the case in other members of the genus. It is the only salmon-colored *Gazoryctra* in the S Rocky Mountains. Male genitalic characters distinguishing *wielgusi* from at least some other members of the genus follow: tergal lobes nearly as high as broad, valva boot-shaped, vinculum ventrolaterally emarginate, trulleum very elongate.

Distribution. White Mountains of E Arizona and adjacent ranges in New Mexico between 2400 and 2800 m elev.

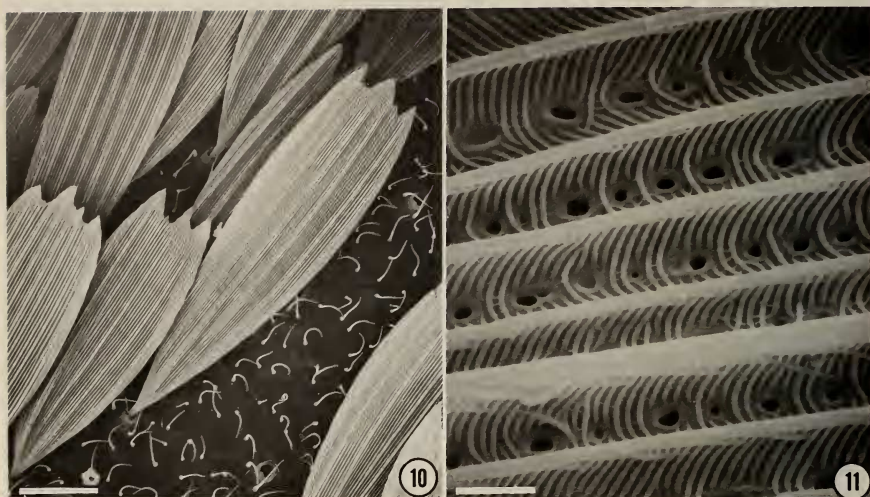
Material examined. 94 males. Holotype: Male, Arizona, Apache Co., 14.4 km E McNary, Ditch Camp, 2400 m, 25-VII-1974, R. S. Wielgus, at ultraviolet and white light, DLW Slide No. 86-66. Deposited in Los Angeles County Museum. Paratypes: Arizona: Apache



FIGS. 6-9. *Gazoryctra wielgusi* male. 6, Antenna showing abundance of sensory setae and cuticular projections. Scale = 43 μ m; 7, Distal antennal segments. Scale = 43 μ m; 8, Protibia. Fusiform scales (arrows) appear dark and spinelike against salmon-colored squamose scales. Scale = 60 μ m; 9, Metathoracic tibial spurs. Scale = 100 μ m.

Co., same data as above, 25-VII/14-VIII-1974/80, R. S. Wielgus, 58 males (Fig. 2), and 26/29-VII-1978, N. B. & M. Tindale, 2 males; White Mtns., Greer, 2600 m, 4-VIII-1962, E. & I. Munroe, 4 males; Greer, 0.8 km S, Government Springs, 6-VIII-1977, R. S. Wielgus, 2 males, and 28/30-VII-1978, N. B. & M. Tindale, 10 males; Greer, 19.2 km SW, Winn Cmpgd., 2800 m, 26-VII-1986, R. Robertson, 12 males; Greenlee Co., Hannagan Meadow, "12-IV-1975", A. Menke, 3 males. New Mexico: Catron Co., Gila Wilderness, along route 78, Willow Creek Cmpgd., ca. 2400 m, 28-VII-1978, 1947 h MST, R. S. Wielgus, 1 male; Indian Creek nr. Gilita Cmpgd., 2400 m, 29-VII-1978, 1948 h MST, R. S. Wielgus, 1 male.

The three specimens of *G. wielgusi* in the USNM bearing the data "CALIFORNIA:



FIGS. 10, 11. *Gazoryctra wielgusi* scales from medial region of male forewing. 10, Scale showing typical exoporian arrangement of primary and secondary ridges. Scale = 30 μm ; 11, Scale ultrastructure: scutes and flutes well developed. Scale = 1.15 μm .

Greenlee Co., Hannagan MDW., April 12, 1975, A. Menke" are mislabeled as there is no Greenlee Co., California. Moreover, all *Gazoryctra* species are summer- or fall-flyers. Presumably, Menke captured the moths in Hannagan Meadow during a collecting trip to the Southwest in August 1975 (A. Menke pers. comm.).

Paratypes are deposited at Arizona State University, Tempe; Australian National Insect Collection, Canberra; British Museum (Natural History), London; California Academy of Sciences, San Francisco; Canadian National Collection, Ottawa; Los Angeles County Museum, California; South Australian Museum, Adelaide; United States National Museum, Washington, D.C.; University of California, Berkeley and Davis; Zoologische Staatssammlung, Munich.

Biology. *Gazoryctra wielgusi* has a very brief period of adult activity. All specimens have been captured in early evening just after onset of darkness. In late July, the main flight occurs between 1945 and 2000 h MST (N = 17); by mid-August flight starts as early as 1930 h MST (N = 7). All specimens (males) were collected at light; typically they are the first moths to arrive at sheets. Adults are most numerous after afternoon rains and may even fly during strong rains (R. S. Wielgus pers. comm.).

Our records are from mesic areas in conifer forests. The locality at Ditch Camp is an open ponderosa pine forest with abundant grasses in open areas and nearby alders. Higher-elevation localities have more understory shrubbery. Spruce is dominant at the two sites in New Mexico. Nothing is known of the early stages. The larvae presumably are polyphagous, subterranean feeders, as are other Holarctic hepialids (Heath 1976, Wagner 1985, 1987). Recorded hosts for other *Gazoryctra* include *Betula*, *Phlox*, *Picea*, and grasses (Wagner 1985, Tham et al. 1985).

Etymology. We name this moth after Ronald S. Wielgus whose seemingly inexhaustible collecting efforts produced most of the known specimens and biological data.

Discussion

Gazoryctra is confined to the Holarctic Region; 10 Nearctic and 3 Palearctic species are recognized. No member is recognized from both

faunas, although the markings of both *ganna* and *macilenta* approach those of *hyperborea* from North America.

Gazoryctra appears to represent one of the most primitive genera of Hepialidae. No synapomorphies have been identified that link *Gazoryctra* to other hepialids. In the past, the absence of tibial spurs has been used to define Hepialidae (Borror & White 1970, Kristensen 1978a, Nielsen & Robinson, 1983). Yet members of *Gazoryctra* possess a pair of small tibial spurs (Fig. 9, Viette 1949, Wagner 1985). In addition, the trulleum is free from the tegumen caudad in *Gazoryctra*, but fused in more derived Hepialidae (Nielsen & Scoble 1987).

Both adults and immature stages of *Gazoryctra* are rare in collections. Only three new hepialids have been described from North America since the turn of the century, and all belong to *Gazoryctra*. Moreover no specimens of *sciophanes* and *wielgusi* were known before 25 years ago. The biology is not known in detail for any species.

ACKNOWLEDGMENTS

M. A. Tenorio assisted with scanning electron microscopy and darkroom work. E. S. Nielsen, G. S. Robinson, M. J. Scoble, W. J. Pulawski, V. Lee, and T. E. Miller offered many helpful suggestions on the manuscript. We thank P. T. Dang, Biosystematics Research Institute, Ottawa, Canada; D. R. Davis, Smithsonian Institution, Washington, D.C.; J. P. Donahue, Los Angeles County Museum, California; and R. G. Robertson for loans of material. This work was supported in part by a Tilton Fellowship to DLW from the California Academy of Sciences, San Francisco, California.

LITERATURE CITED

Items marked by * were not seen by present authors.

- BARNES, W. & F. H. BENJAMIN. 1926 (1925). The *hyperboreus* group of *Hepialus* (Lepidoptera: Hepialidae). Pan-Pac. Entomol. 2:81-84.
- BIRKET-SMITH, S. J. R. 1974. Morphology of the male genitalia of Lepidoptera. II. Monotrysis, Zeugloptera, and discussion. Entomol. Scand. 5:161-183.
- *BÖRNER, C. 1925. Lepidoptera, pp. 358-387. In Brohmer, P. (ed.), Fauna von Deutschland. Quelle & Meyer, Leipzig.
- BORROR, D. J. & R. E. WHITE. 1970. A field guide to the insects of America north of Mexico. Houghton Mifflin, Boston. 404 pp.
- BROWN, F. M. 1964 (1963). Dates of publication of the various parts of the Proceedings of the Entomological Society of Philadelphia. Trans. Am. Entomol. Soc. 89:305-308.
- DAVIS, D. R. 1983. Hepialidae, p. 2. In Hodges, R. W., et al. (eds.), Check list of the Lepidoptera of America north of Mexico. E. W. Classey Ltd., London.
- DOWNEY, J. C. & A. C. ALLYN. 1975. Wing-scale morphology and nomenclature. Bull. Allyn Mus. 31:1-32.
- FERGUSON, D. C. 1979. A new ghost moth from the southern Appalachian Mountains (Hepialidae). J. Lepid. Soc. 33:192-196.
- FORBES, W. T. M. 1923. The Lepidoptera of New York and neighboring states. Cornell Univ. Agr. Exp. Stat. Mem. 68:1-729.
- HEATH, J. 1976. Hepialidae, pp. 166-170. In Heath, J. (ed.), The moths and butterflies of Great Britain and Ireland. Curwell Science Press, London.
- HEMMING, F. 1937. Hübner: A bibliographical and systematic account of the entomological works of Jacob Hübner. Roy. Entomol. Soc. Lond. Vol. 1 605 pp; Vol. 2 271 pp.

- HÜBNER, J. [1820]. Verzeichniss bekannter Schmettlinge. Privately printed, Augsburg. Pp. 198–199. (Dating after Hemming 1937.)
- KIRBY, W. F. 1892. A synonymic catalogue of Lepidoptera Heterocera. (Moths). Vol. 1. Sphingae and Bombyces. Gurney & Jackson, London. Pp. 879–894.
- KRISTENSEN, N. P. 1978a. A new familia of Hepialoidea from South America, with remarks on the phylogeny of the subordo Exoporia (Lepidoptera). *Entomol. Germ.* 4:272–294.
- 1978b. Ridge dimorphism and second-order ridges in wing scales in Lepidoptera: Exoporia. *Int. J. Insect Morphol. Embryol.* 7:297–299.
- MCDUNNOUGH, J. H. 1939. Check list of the Lepidoptera of Canada and the United States of America. Part II. Microlepidoptera. *Mem. So. California Acad. Sci.* 2:1–171.
- NEUMOEGEN, B. & H. G. DYAR. 1894. Preliminary revision of the Bombyces of America north of Mexico. *J. New York Entomol. Soc.* 2:147–174.
- NIELSEN, E. S. & N. P. KRISTENSEN. In press. Primitive ghost moths: Morphology and taxonomy of the Australian genus *Fraus* Walker (Lepidoptera: Hepialidae s. lat.). E. J. Brill, Leiden.
- NIELSEN, E. S. & G. S. ROBINSON. 1983. Ghost moths of southern South America (Lepidoptera: Hepialidae). *Entomonograph Vol. 4.* Scandinavian Science Press, Copenhagen. 192 pp.
- NIELSEN, E. S. & M. J. SCOBLE. 1987. *Afrotheora*, a new genus of primitive Hepialidae from Africa (Lepidoptera: Hepialoidea). *Entomol. Scand.* 17:29–54.
- PACKARD, A. S. 1865 (1864). Synopsis of the Bombycidae of the United States. *Proc. Entomol. Soc. Philadelphia* 3:331–396. (Dating after Brown 1964.)
- PFITZNER, R. 1912. Familie: Hepialidae, pp. 433–439, pls. 53, 54. *In* Seitz, A. (ed.), *Die Gross-Schmetterlinge der Erde*. 1 (8). Kernan, Stuttgart.
- 1937–38. Familie: Hepialidae, pp. 1289–1302, pls. 99, 185. *In* Seitz, A. (ed.), *Die Gross-Schmetterlinge der Erde*. 6 (4). Kernan, Stuttgart. (Often cited as R. Pfitzner & M. Gaede.)
- ROBINSON, G. S. 1977. A taxonomic revision of the genus *Callipielus* Butler (Lepidoptera: Hepialidae). *Bull. Brit. Mus. (Nat. Hist.) (Entomol.)* 35:101–121.
- THAM, E., H. ELMQUIST & H. TREI. 1985. Larval biology of *H. fuscoargenteus* Bang-Haas (Lep.: Hepialidae). *Entomol. Tidskr.* 106:43–44.
- UEDA, K. 1978. The male genital structure of some hepialid moths with a historical review of their terminology. [Japanese, English summary.] *Tyô to Ga* 29:191–206.
- VIETTE, P. E. L. 1948. Lépidoptères Homoneures. *Faune de France*. Vol. 49. Lechevalier, Paris. 83 pp.
- 1949. Contribution à l'étude des Hepialidae (12^e note). *Genres et synonymie. Lambillionnea* 49:101–104.
- 1953. Contribution à l'étude des Hepialidae (30^e note). *Lambillionnea* 53:32–35.
- WAGNER, D. L. 1985. The biosystematics of *Hepialus* F. s. lato, with special emphasis on the *californicus-hectoides* species group. Ph.D. Dissertation, University of California, Berkeley. 391 pp. Diss. Abstr. Order No. DA8610260.
- 1987. Hepialidae, pp. 347–349. *In* Stehr, F. (ed.), *Immature insects*. Kendall-Hunt, Dubuque, Iowa.
- WAGNER, H. & R. PFITZNER. 1911. Hepialidae. *Lepidopterorum Catalogus* 4:1–26.
- *WALLENLUND, H. D. J. 1869. Skandinaviens Heterocer-fjarilar. 2 vols. C. Bulow, Lund. 256 pp.

Received for publication 20 February 1987; accepted 25 April 1988.